Assessment of Natural Gas Combined Cycle (NGCC) Plants with CO2 Capture and Storage

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California Energy Commission
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Agenda

1:30 Welcome and Introductions
Mike Gravely - Energy Commission

1:40 Overview of the Energy Commission's WESTCARB efforts
Elizabeth Burton – WESTCARB Technical Director

1:55 Administrative Logistics
Andrew Ferrin - Energy Commission

2:20 Administrative Q&A
Andrew Ferrin - Energy Commission

2:30 Break

2:45 Bevilacqua-Knight, Inc's Role and Reference Documents
Rich Myhre – Bevilacqua-Knight, Inc

3:05 Pacific Gas & Electric's Role
Emma Wendt – Pacific Gas & Electric

3:25 Livermore National Laboratory's Role and Reference Documents
Elizabeth Burton – WESTCARB Technical Director

3:45 Open Discussion (Q&A)

California Energy Commission Responsibilities

- Forecasting future energy needs and keeping historical energy data.
- Licensing thermal power plants 50 megawatts or larger.
- Promoting energy efficiency by setting the state's appliance and building efficiency standards and working with local government to enforce those standards.
- Supporting renewable energy by providing market support to existing, new, and emerging renewable technologies; providing incentives for small wind and fuel cell electricity systems; and providing incentives for solar electricity systems in new home construction.
- Implementing the state's Alternative and Renewable Fuel and Vehicle Technology Program.
- Planning for and directing state response to energy emergencies.
- Supporting public interest energy research that advances energy science and technology through research, development, and demonstration programs.

PIER Program Overview

- IOU Ratepayer Funded Program
- Launched in 1997 by AB1890
- $86.5 Million Annual Budget FY 10/11
  - $62.5 million electric
  - $24 million natural gas
- Program Research Areas
  - Energy Efficiency & Demand Response
  - Renewable Energy & Advanced Electricity Generation
  - Transmission & Distribution
  - Climate & Environment
  - Transportation

Legislation and PIER

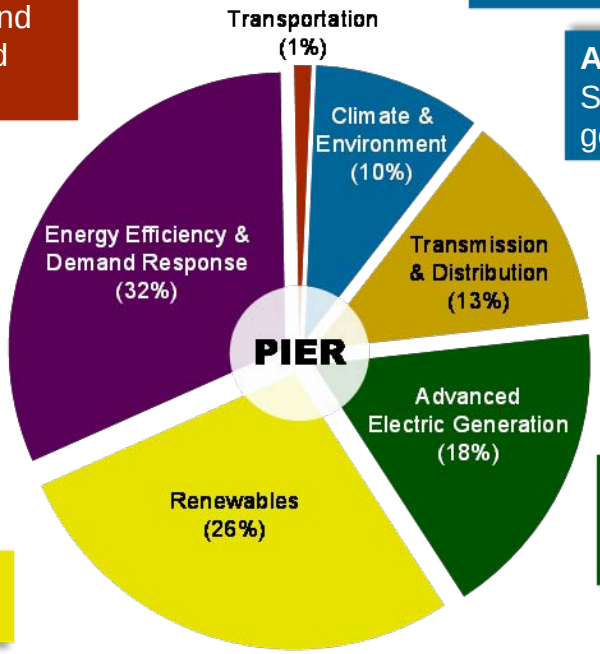
Funding Total: $587.7 million from 1997 - 2008

SB 375 – Land-Use Planning and GHG Emissions

AB 1007 – Transportation and Alternative Fuels

SB 1368 – GHG Emissions standards for POUs

AB 118 – Alternate and Renewable Fuels and Vehicles Deployment



AB 32 – Global Warming Solutions Act of 2006; aggressive goals for 2020

AB 2021 – Energy Efficiency for POUs

SB 1250 – PIER and Renewables Incentive Programs Reauthorized

AB 2160 – Green Building Acquisition Financing for State Facilities

AB 2778 – Self-Generation Incentive Program for Fuel Cells and Wind

SB 107 – Accelerated RPS Goals

SB 1250 – PIER and Renewables Incentive Programs Reauthorized

SB 1 – Renewables Goals for New and Existing Residential and Commercial Structures

PIER Smart Grid Research Ongoing at all Levels

Transmission

- Phasor Measurement
- Advanced displays
- Advanced comm & controls
- MRTU interface
- Energy Storage
- Renewables

Distribution

- Distribution Automation
- AMI
- Advanced C&C
- MRTU
- Energy Storage
- Renewables

Integration

- Renewables
- Standards
- Protocols
- Reference designs
- Micro Grids
- Automation
- Energy Storage

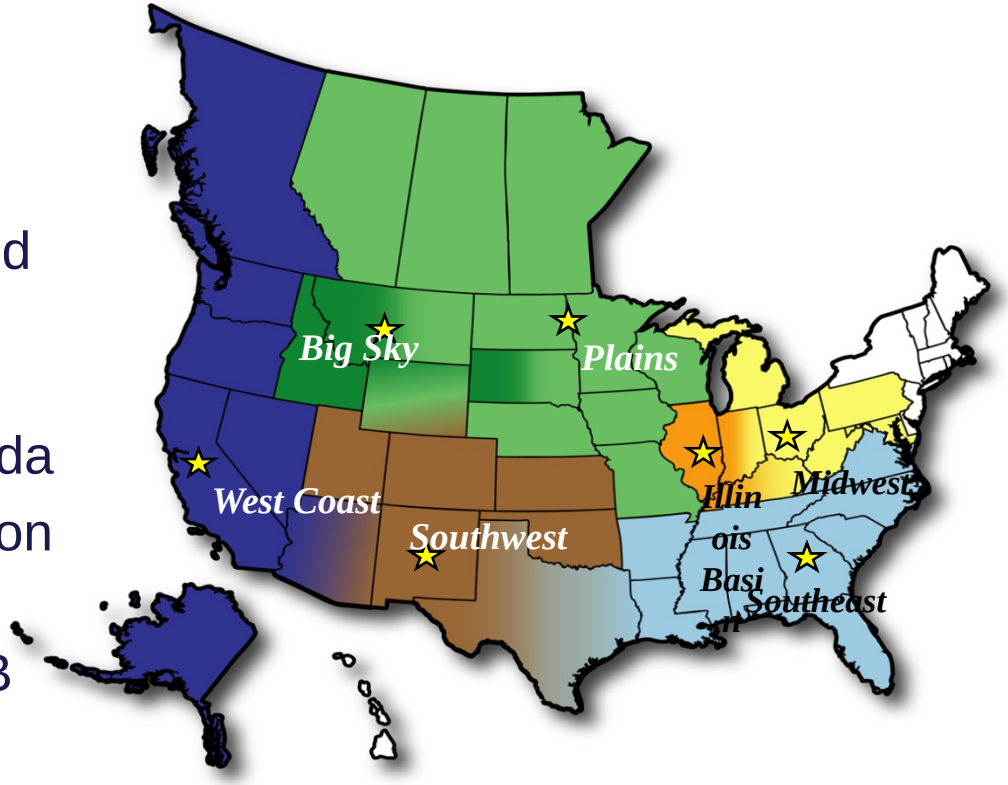
Consumer

- Automating Demand Response
- AMI
- Dynamic Rates
- Home Area Networks
- Plug in Hybrids
- Renewables
- Energy Storage

Background

WESTCARB: One of Seven Regional Carbon Sequestration Partnerships

- DOE program initiated in 2003
- Opportunities for geologic and terrestrial CO_2 storage evaluated throughout U.S. and Canada
- Over 350 participating organizations in U.S. and Canada
- Program focus on implementation issues
- Hawaii now part of WESTCARB



WESTCARB Budget History

	Phase I	Phase II	Phase III
	2 years	4 years	10 years
Federal – including direct funding to national labs	1,600,000	17,931,100	65,606,584
PIER**	1,686,912	2,554,712	5,268,418
Third-Party Cost Share	264,000	7,896,446	19,719,100
TOTAL	3,550,912	28,382,258	90,594,102

Proposed Contract Tasks

1) Evaluation of CO_2 capture technology options for use on NGCC plants

2) An engineering and economic assessment report of the installation and operation of CCS technologies in both retrofit and new-build applications, at California utility-scale NGCC plants

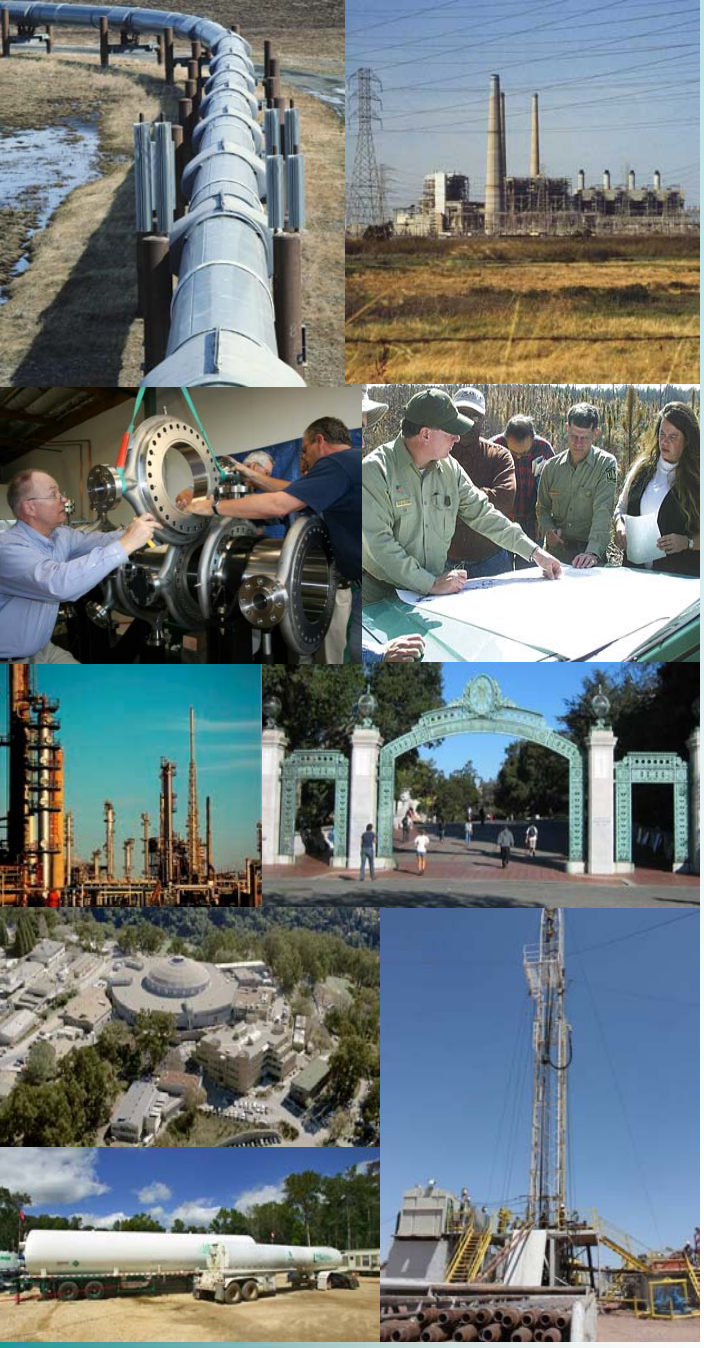
3) Preliminary design for a pilot-scale CO_2 capture, compression/dehydration, and injection well test facility

West Coast Regional Carbon Sequestration Partnership

WESTCARB Overview

Elizabeth Burton
WESTCARB Technical Director

California Energy Commission
NGCC Pre-Bid conference
November 3, 2010

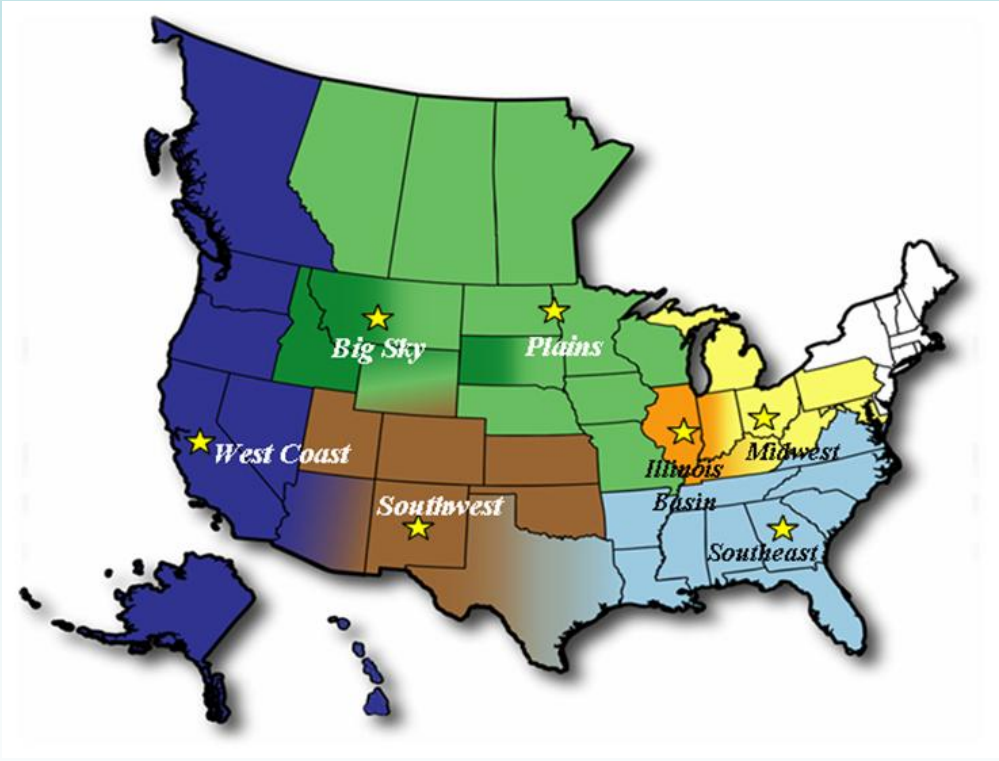


WESTCARB is

- A project funded by the U.S. Department of Energy, the Energy Commission, and industrial partners
- A team of researchers from more than 90 organizations:
  - National laboratories and research institutions
  - Resource management and environmental protection agencies
  - Conservation nonprofits
  - Climate project standards organizations
  - Energy, utility, and pipeline companies
  - Colleges and universities
  - Trade associations
  - Consultants
- Administered by the California Energy Commission with Lawrence Berkeley and Lawrence Livermore National Laboratories

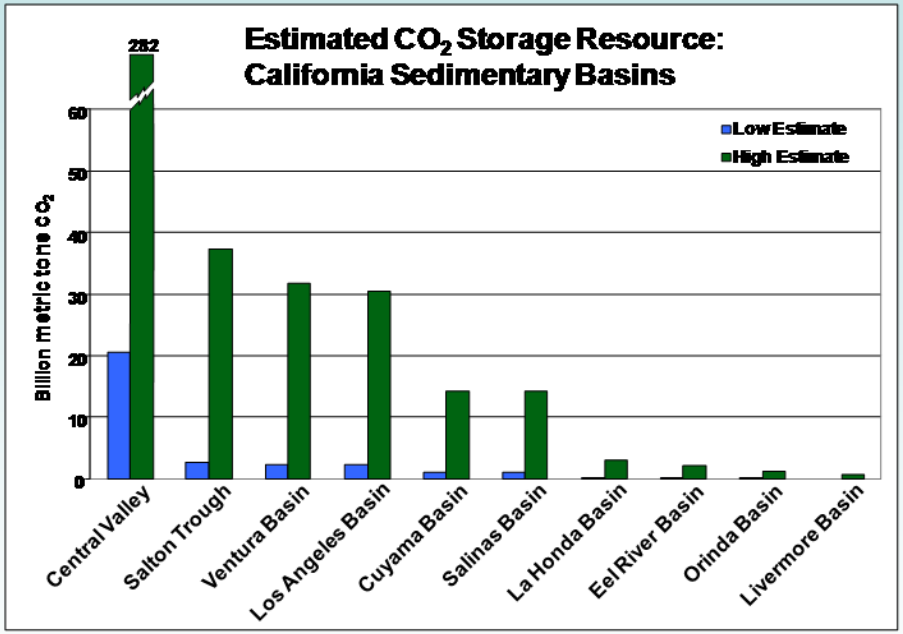
WESTCARB is one of seven DOE Regional Carbon Sequestration Partnerships (RCSPs)

- Three phases :
  - Characterization Phase (2003-2005) opportunities for carbon sequestration
  - Validation Phase (2005-2011) Small scale field tests and regional characterization
  - Development Phase (2008-2018) large volume carbon storage tests and regional characterization
- Seven partnerships with 350+ members
- Six countries from the Carbon Sequestration Leadership Forum participating in Validation Phase



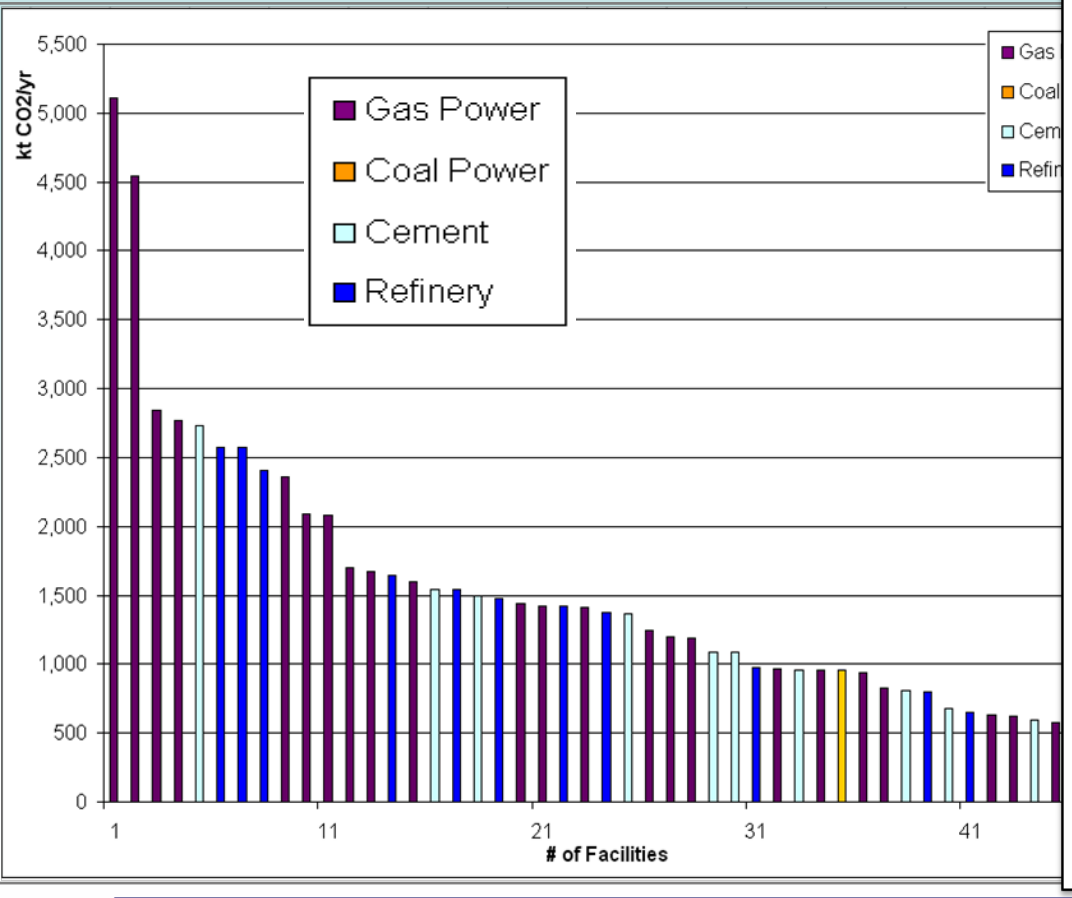
WESTCARB includes Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and British Columbia

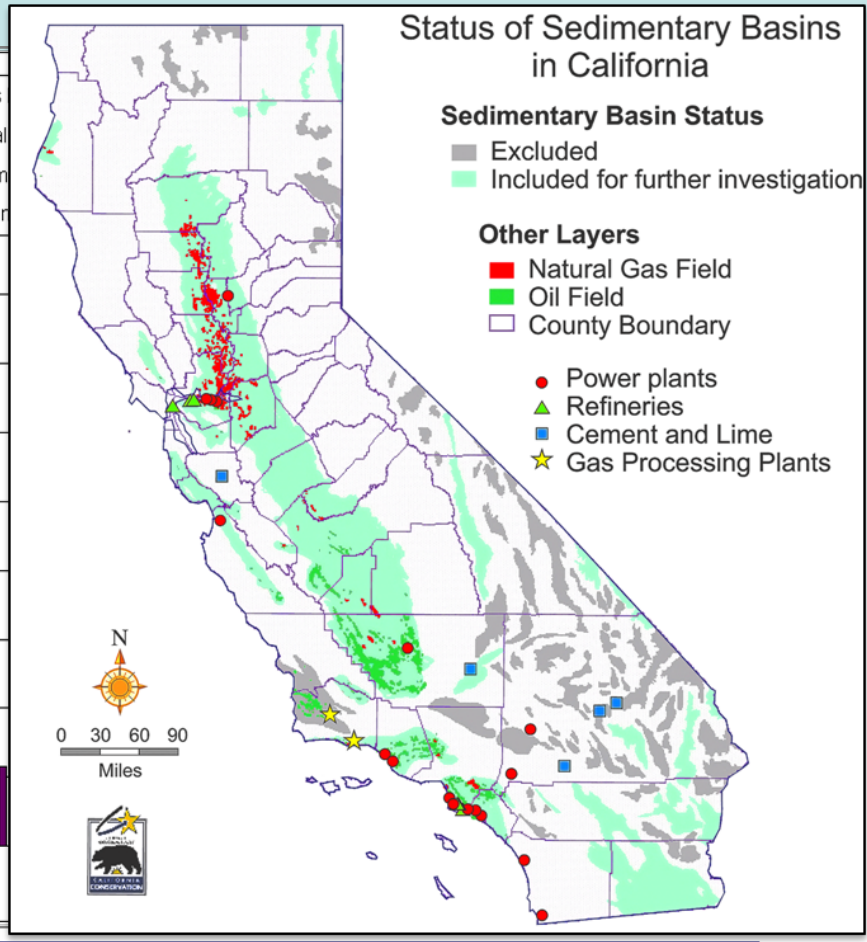
An important part of WESTCARB's mission is characterizing the geologic storage potential in its region



30–460 GT onshore saline formation capacity
3.3–5.7 GT natural gas reservoir capacity
1.4 –3.7 GT oil reservoir capacity

WESTCARB also characterizes CO_2 emissions point sources throughout its region: in California, the largest are natural gas power plants, cement plants, and refineries





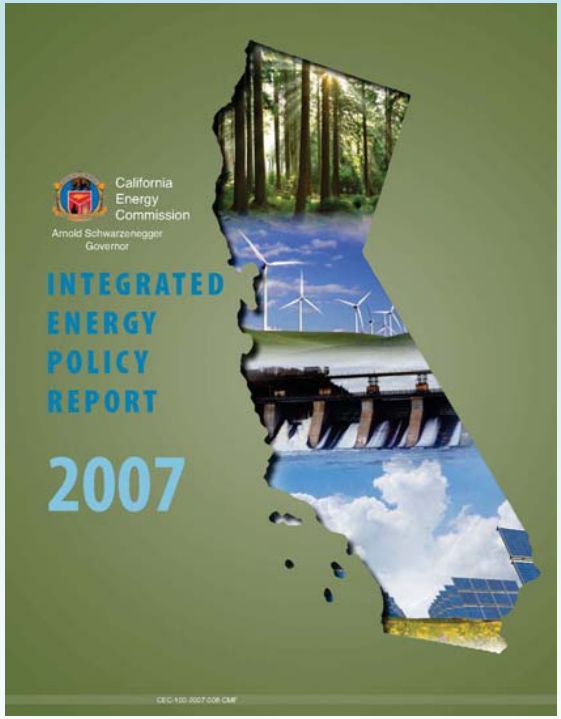
90% are within 50 km of a potential sequestration site

WESTCARB has a strong public education and outreach program

- Community meetings throughout WESTCARB's territory
- Middle and high school science teachers' training
- Contributions to public domain information on CCS
  - Website and interactive carbon atlas
  - Project reports
  - DOE "best practices" manuals
- Public perception research
- International knowledge-sharing

WESTCARB research helps inform policymaking for CCS

- CCS workshops for the 2005, 2007, and 2009 Integrated Energy Policy Reports
- AB 1925 report to the California Legislature
- AB 32 framework for GHG emissions reductions
- Oregon – House bill 3543 GHG emissions reductions (forest sequestration)
- Washington – Senate bill 6001 GHG emissions reductions
- Nevada – Senate bill 422 GHG emissions reporting



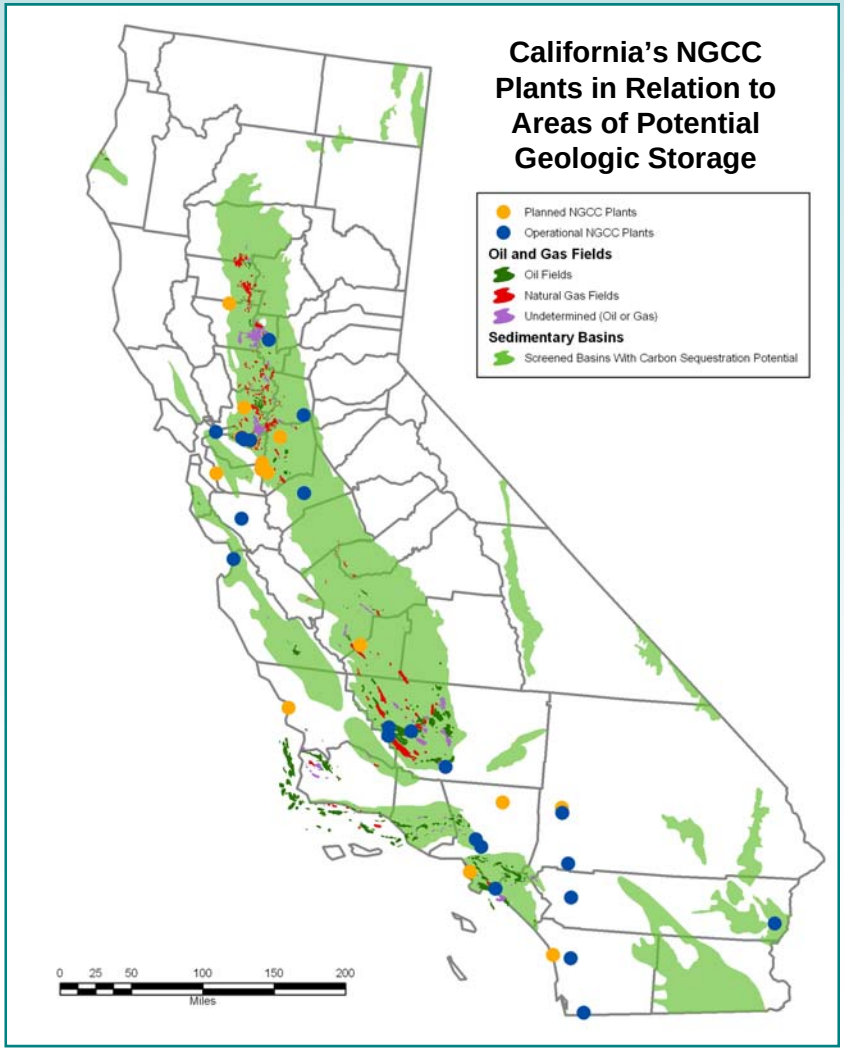
WESTCARB provides support to the California Carbon Capture and Storage Review Panel

- Panel was convened by California agencies (CEC, CPUC, CARB) to draft recommendations to agencies and the legislature for CCS
- WESTCARB researchers are serving on the Technical Advisory Committee providing background papers, presentations, and writing support
- Five public meetings of the Panel are being held
- Final report by the Panel is due at year-end 2010

Panel website:
http://www.climatechange.ca.gov/carbon_capture_review_panel/meetings/index.html

WESTCARB's NGCC-CCS study provides an important step toward commercializing CCS in California

- Approximately 50 F-Class (and a couple of H-Class) gas turbines have been commissioned in California since 1998
- Units considered candidates for future CCS retrofit
  - Supportive plant site characteristics for CO_2 capture
  - Dispatch mode and remaining life
  - Proximity to suitable geologic storage sites and pipelines
- Working with PG&E, which is developing a GHG compliance strategy



Assessment of Natural Gas Combined Cycle Plants for Carbon Dioxide Capture and Storage in a Gas-Dominated Electricity Market

California Energy Commission

Request for Proposals

RFP # 500-10-502

Pre-Bid Conference

Date: Wednesday, November 3, 2010

Proposal Requirements

REQUIRED FORMAT FOR PROPOSAL RESPONSE

Consists of Two Sections:

- Section 1 – Administrative Section
- Section 2 – Technical & Cost Section

Section 1:
Administrative Response

Cover Letter	
Table of Contents	
Contractor Status Form	Attachment 1
Contractor Certification Clauses	Attachment 2
Small Business Preference Certification	If applicable
Completed Disabled Veteran Business Enterprise form Std 843	Attachment 5
Bidder Declaration form GSPD-05-105	Attachment 6
California Based Entity Questionnaire (CBE)	Attachment 8
Target Area Contract Preference Act Std 830	Attachment 9
Enterprise Zone Act Preference (Eza) Request Std 831	Attachment 10
Local Agency Military Base Recovery Area Act Std 832	Attachment 11
Darfur Contracting Act Certification	Attachment 12

Section 2:
Technical and Cost Section

Scope of Work	Attachment 13
Approach to Tasks in Scope of Work	See Page 12
Team Organizational Structure	See Page 12
Labor Hours by Personnel and Task	See Page 13
Project Team Experience and Qualifications	See Page 13
Budget Forms	Attachment 14
Customer References	Attachment 15
Previous Work Products	See Page 13

Small/Non-Small Business Preference

- Small Business Preference – California State Certified Small Businesses or micro-businesses can claim the five percent preference when submitting a proposal. See RFP, page 14and attachment 3 for more information.
- Non-Small Business Preference – Bidder commits to small or micro business subcontractor participation of 25% of net bid price. See RFP, page 14 and attachment 3 for more information.

California-Based Entity Preference

1. To receive CBE Preference, the proposal must include a CBE as either the prime contractor/recipient or a subcontractor. A CBE is a corporation or other business form organized for the transaction of business that:
   - Either has its headquarters or an office in California AND
   - Substantially manufactures the product or substantially performs the research within California that is the subject of the award.
2. The budget must show that the CBE(s) will receive 50% or more of the PIER funds awarded.

California-Based Entity (Cont.)

3. The proposal must receive a passing score prior to any preference points being added. The preference points will be awarded as follows:

Base Score (score prior to any preference points being added)	CBE Preference Points
700-759	10
760-819	20
820-879	30
880-939	40
940-1000	50

Disabled Veteran Business Enterprise (DVBE) Requirements

Bidder must commit to meet or exceed the DVBE participation requirements of 3% of the total Bid amount by either of the following methods:

Method A1 – Proposer is a Certified DVBE

Method A2 – Subcontractor is a certified DVBE and will receive at least 3% of the Agreement amount

DVBE (cont'd)

A copy of an Agreement between the Contractor and the DVBE must be submitted prior to contract award. The Agreement may be in draft form but must show that the DVBE meets the Commercially Useful Function requirements as defined in the RFP.

DVBE (cont'd)

Incentive

The DVBE Incentive Program gives a contractor an opportunity to improve their bid status based on the efforts attained from the DVBE Participation Program. DVBE information is located in Attachments 3, 4 and 5.

Proposed DVBE Participation Level	DVBE Incentive % Point Preference	DVBE Incentive Points
3.01% - 3.99%	1%	10
4% - 5%+	2%	20

Tentative Key Activities and Dates

ACTIVITY	ACTION DATE
RFP Release	October 13, 2010
Deadline for Written Questions	November 3, 2010
Pre-Bid Conference	November 3, 2010
Distribute Questions/Answers and Addenda (if any) to RFP	November 12, 2010
Deadline to Submit Proposals by 3:00 p.m.	December 1, 2010
Clarification Interviews (If necessary)	December 13, 2010
Notice of Proposed Award	January 13, 2011
Commission Business Meeting	March, 2011
Contract Start Date	April, 2011
Contract Termination Date	September, 2011

Questions and Answers

Question and Answer Session

Whom to Contact

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California Energy Commission
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Sacramento, CA 95814
(916) 654-4379
(916) 654-4423 (fax)
rgrant@energy.state.ca.us

Assessment of NGCC with CCS

Technical Task Approach and WESTCARB Preliminary Assessment

Rich Myhre
Vice President
Bevilacqua-Knight, Inc.
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RFP 500-10-502 Pre-Bid Workshop
November 3, 2010

Project Background and Objective

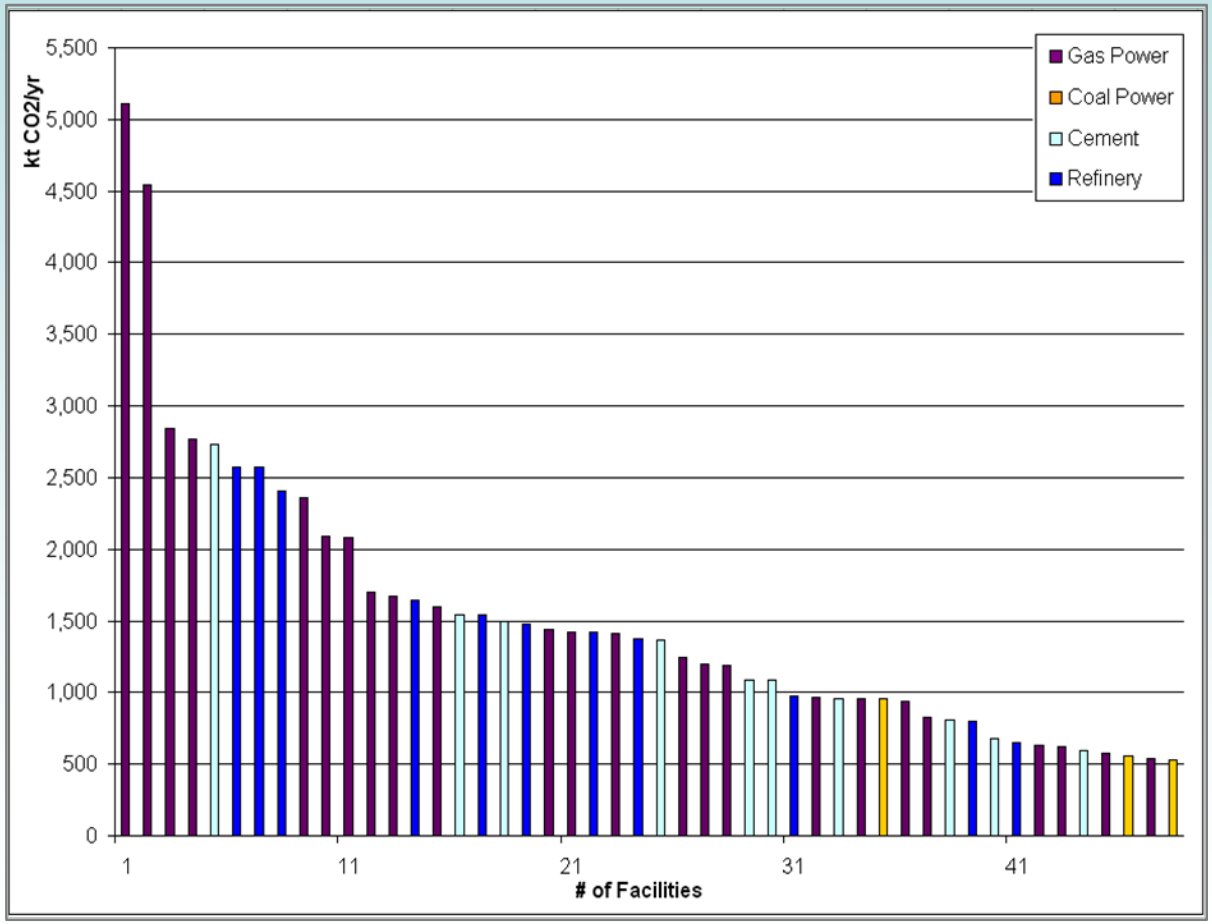
- WESTCARB has historically focused on CO_2 storage, with limited assessments of CO_2 capture technologies; this RFP aims to better understand capture issues for California's largest point source type—natural gas-fired combined cycle power plants
- What CO_2 capture technologies are the best candidates for application on NGCC power plants in California?
  - Retrofits to the existing fleet
  - New-build units
  - Location-specific challenges or goals, such as water availability/ quality, grid reliability initiatives, air quality improvement, etc.
  - Timeframe of application
- What are their cost, performance, and operational impacts?

Project Background and Objective (cont'd)

- How many (and which) California generating units could be considered candidates for future CCS retrofit?
  - Supportive site/design characteristics for CO_2 capture
  - Dispatch mode (capacity factor, duty cycle) and remaining life conducive to economic justification
  - Reasonable options for CO_2 transportation and storage
  - Strategic or commercial factors
- Insight into "real world" issues gained by working with one or more major utilities developing a GHG/RPS strategy while remaining accountable to customers, employees, regulators, shareholders, etc.
- What is the best approach (and cost and leadtime) for testing a promising CCS application, at pilot-scale, on an NGCC unit or NG-fired cogeneration unit in California?

California NGCC Units

- Approximately 50 F-Class (and two H-Class) gas turbines have been commissioned in California since 1998
- With relatively high capacity factors, some of these units are among the state's top CO_2 producers



Source: J. Katzer and H. Herzog, MIT, in *Geologic Carbon Sequestration Strategies for California,* CEC 500-2007-100-CMF, 2008.

Project Approach Embodied in RFP 500-10-502 Task Structure

- Screen a broad set of candidate CO_2 capture processes applicable to NGCC power plants
  - Pre-combustion
  - Post-combustion
  - Oxy-combustion
  - Emerging technologies
- Screen California NGCC plant sites—current and planned or under construction—for CCS suitability
- Review capture technology and plant screening results with Project Advisory Committee composed of PG&E (and possibly additional power generators), LLNL, and Energy Commission staff and contractors (BKi)

Project Approach Embodied in RFP 500-10-502 Task Structure (cont'd)

- Examine a subset of CO_2 capture technologies in greater detail, assuming application to a nominal 550 MW NGCC plant with 2x1 F-class gas/steam turbine configuration
- Benchmark NGCC-CCS performance against alternative generating technologies, such as coal/coke IGCC-CCS, PC/FBC-PCC, waste-to-energy, other
- Identify permitting pathway(s) and any significant differences among capture approaches
- Review findings with Project Advisory Committee

Project Approach Embodied in RFP 500-10-502 Task Structure (cont'd)

- Build/adapt model to conduct engineering-economic evaluations of specific California plant site and capture technology combinations (based on mutual selection with Project Advisory Committee)
- Apply model to retrofit and new-build cases
- Conduct select sensitivity analyses
- Review results with Project Advisory Committee
- Work with Project Advisory Committee to select a CO_2 capture technology type, location, and storage approach to test integrated NG-CCS at pilot or pre-commercial scale

Project Approach Embodied in RFP 500-10-502 Task Structure (cont'd)

- Develop a feasibility study or "pre-FEED type" site-specific preliminary engineering design, cost estimate, and schedule
  - Adapt/develop process flow diagrams, heat and mass balances, equipment layouts, bulk material quantities, emissions, and other information, within project resources
  - Identify permitting requirements (surface and subsurface) and expected timetable
  - Develop a Gantt chart showing major tasks and dependencies for detailed design, procurement, and construction

RFP 500-10-502 Technical Tasks

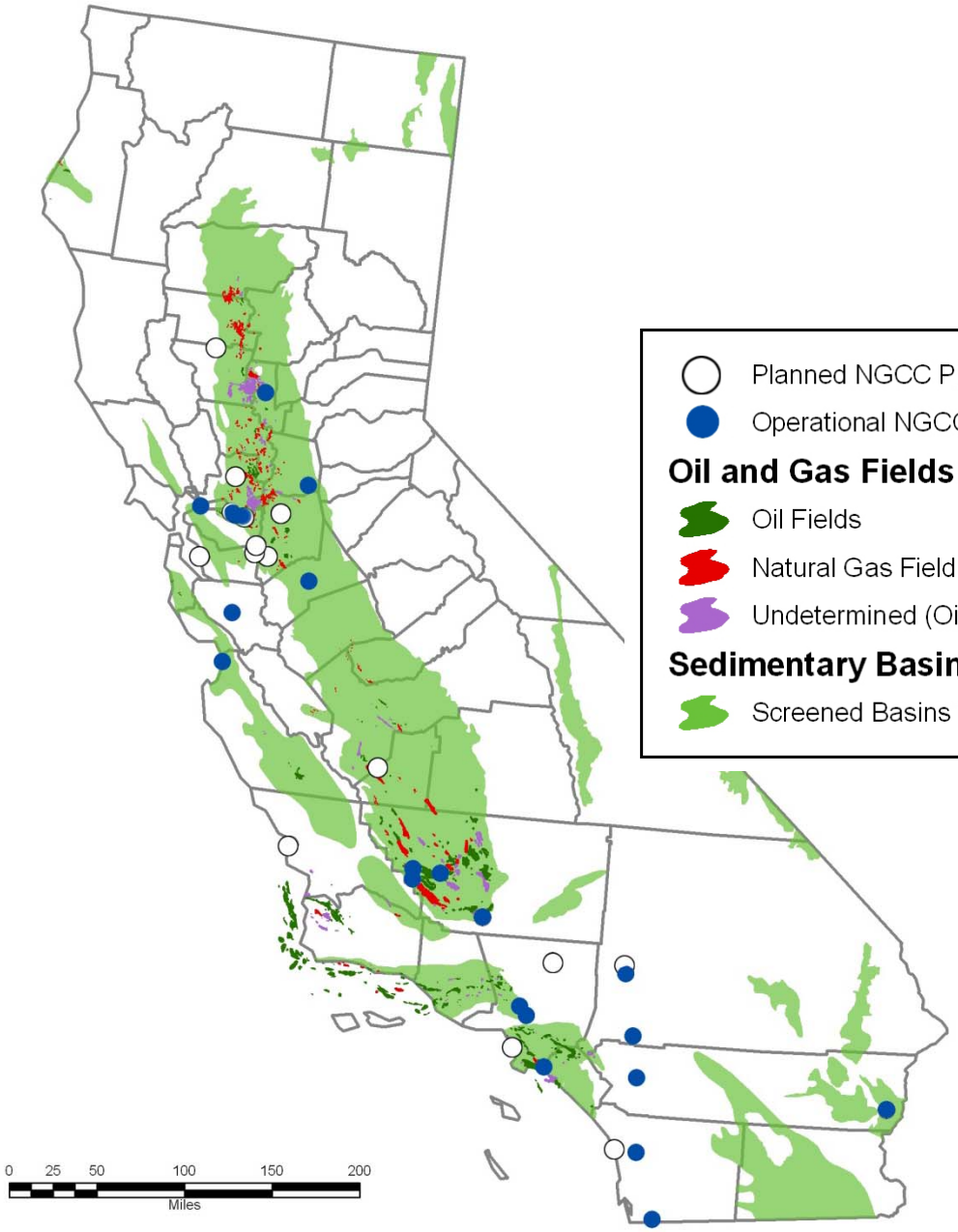
- Task 2: Overall Assessment of California NGCC Plants and CO_2 Capture Technologies for Retrofit
- Task 3: Engineering Options Analysis Procedure, Site Assessment, and Preliminary Engineering Design for CO_2 Capture Retrofit and New-Build Cases
- Task 4: Preliminary Scope, Cost, and Schedule Estimate for a California Pilot-Scale Technology Validation Test of an NGCC Plant with CCS Application

WESTCARB "Preliminary Assessment"

- Table of design and operating data for existing and planned* utility-scale (i.e., F, G, or H class) NGCC plants in California
- Cursory observations of available plant space to accommodate CO_2 capture and compression equipment at existing plants
- Map of current and planned NGCC plant locations relative to sedimentary basins screened by California Geological Survey as candidate for CO_2 storage
- Tabulation of known CO_2 capture processes with brief synopses

* Planned = Under construction, approved/on-hold, and in review, but not approved/expired or cancelled

NGCC Unit Proximity to Potential CO_2 Sinks



WESTCARB Preliminary Assessment: What We Did

- Assembled design, capacity factor, and emissions data from public sources: EPA, eGRID, EIA-923 operations reports, Energy Commission siting documents, and plant owner websites
- Requested plot plans from California NGCC plant operators
- Reviewed plant aerial images in Google Earth; assessed “room for CCS equipment” on crude visual basis drawing upon DOE NETL “Conesville Study”
- Examined siting documents on file at the Energy Commission for information on cooling water source(s)

WESTCARB Preliminary Assessment: What We Didn't Do

- Did not engineer any equipment for any capture technology for any California plant
- Did not contact NGCC plant owners or operators to verify information or discuss our observations
- Did not contact permitting or regulatory compliance authorities to verify information or discuss observations

Facilities Siting Division
- Division Main Page
- More About the Division
- Docket Unit
- Contacts Us

Power Plant Siting
- Main Licensing Page
- List of all projects
- Status of all Projects
- Renewable Energy Facilities
- Renewable Energy Federal-State MOUs
- BLM/DOE Solar PEIS

- Database of California Power Plants
- Energy Facility Maps
- Distributed Generation
- AB 1632 Nuclear Assessment
- Greenhouse Gas Emission Impacts of Power Plants
- Siting Data Adequacy Forms

Power Plant Compliance
- Power Plants Licensed Prior to 1999
- Project Filed From 1996 To Present
- Emergency Peaker Projects

Information For Developers
- Licensing Process
- Licensing Fees

Information For Public
- Public Adviser
- Public Participation Guide

Environmental Protection
- Environmental Programs
- Once-Through Cooling
- Avian Guidelines for Wind Project Development
- Greenhouse Gasses

Engineering and Transmission
- Transmission Line Initiatives and Programs
- Strategic Transmission Investment Plan (PDF file)
- SB 1059 Transmission Corridors Designation
- 2005 EPAct Section 368 Federal Energy Corridors

Home » sitingcases » alphabetical

Alphabetical List of Power Plant Projects Filed Since 1996

- Renewable Energy Power Projects - (Proposed projects are listed on our 33% by 2020 page).

- Abengoa Mojave Solar Project - Mojave Solar LLC
- Almond 2 Peaking Power Plant Project - Turlock Irrigation District
- Avenal Energy - Avenal Power Center, LLC

- Beacon Solar Energy Project
- Black Rock 1, 2, and 3 Geothermal Power Project Major Amendment
- Blythe - Blythe Energy LLC
- Blythe II Combined Cycle - Blythe Energy LLC
- Blythe Solar Power Project - Solar Millennium LLC
- Blythe Transmission Line - Blythe Energy LLC
- Border - Calpeak (Emergency Peaker)
- Bottle Rock Geothermal - U.S. Renewables Group (Repower)
- Bullard Energy Center (BEC)

- Canyon Power Plant
- Carlsbad Energy Center - NRG
- Carrizo Energy Solar Farm
- Century - Alliance (Emergency Peaker)
- Chevron Richmond Power Plant Replacement Project - Chevron USA, Inc.
- Chula Vista Energy Upgrade Project - MMC Energy, Inc.
- City of Vernon Malburg Generating Station
- Colusa Generating Station (CGS)
- Community Power - Kings River Conservation District
- CPV Vacaville Station

- Delta - Calpine
- Drews - Alliance (Emergency Peaker)

- East Altamont - Calpine
- Eastshore Power Project - Tierra Energy
- El Centro Unit 3 Repower Project - Imperial Irrigation District (IID)
- El Segundo Repower - Dynegy/NRG
- El Segundo - Dry Cooling Amendment Proceeding
- Elk Hills - Sempra & Oxy
- Escondido - Calpeak (Emergency Peaker)

- Gateway Generating Station - PG&E
- Genesis Solar Energy Project - Genesis Solar LLC / NextEra™
- Gilroy I, Units 1,2 & 3 - Calpine (Emergency Peaker)

- Hanford - GWF (Emergency Peaker)
- Hanford Combined Cycle Power Project - GWF (Major Amendment)
- Henrietta Peaker - GWF
- Henrietta Combined Cycle Power Project - GWF (Major Amendment)
- High Desert - High Desert Power Project LLC
- Highgrove - AES
- Humboldt Bay Generating Station - PG&E
- Huntington Beach Unit 3 & 4 - AES
- Hydrogen Energy California - Hydrogen Energy International LLC

- Magnolia - SoCal Power Authority
- Malburg Generating Station - City of Vernon
- Mariposa Energy Project - Mariposa Energy, LLC
- Marsh Landing Generating Station
- Metcalf - Metcalf Energy Center LLC
- Modesto Irrigation District - Ripon, Simple Cycle
- (Abengoa) Mojave Solar Project - Mojave Solar LLC
- Morro Bay - Duke
- Moss Landing Unit 1 & 2 - Duke
- Mountainview - SCE

- Niland Gas Turbine Plant (SPPE)

- Oakley Generating Station (Formerly Contra Costa Generating Station)
- Orange Grove Energy, Simple Cycle
- Otay Mesa - Calpine

- Palen Solar Power Project - Solar Millennium LLC
- Palmdale Solar-Gas Hybrid - City of Palmdale
- Palomar Escondido - Sempra
- Panoche Energy Center - Energy Investors Fund
- Pastoria - Calpine
- Pastoria Expansion Project (Pastoria 2) - Pastoria Energy LLC

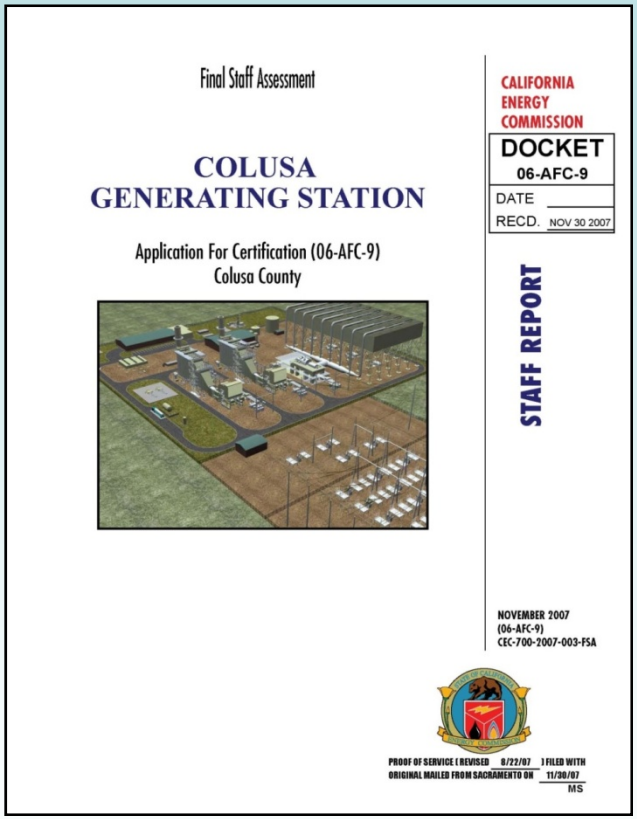
- Rice Solar Energy Project - Rice Solar Energy LLC / SolarReserve LLC
- Ridgecrest Solar Power Project - Solar Millennium LLC
- Riverside Energy Resource Center - City of Riverside Public Utilities
- Riverside Energy Resource Center Units 3 & 4 **(Expansion Project)** - City of Riverside
- Roseville Energy Park - City of Roseville
- Russell City - Calpine
- Russell City **Amendment** - Calpine

- Salton Sea Geothermal
- Salton Sea Geothermal Major Amendment - CE Obsidian Energy, LLC
- San Francisco Electric Reliability Project - City of San Francisco
- San Gabriel Generating Station - Reliant Energy
- San Joaquin Solar 1 & 2 - San Joaquin Solar LLC
- San Joaquin Valley Energy Center - Calpine
- Sentinel Energy Project - CPV Sentinel, LLC
- SMUD Combined Cycle Phase 1
- Solar One Power Project - SES Solar One LLC
- Solar Two Power Project - SES Solar Two LLC
- Southeast Regional Energy Center (Formerly City of Vernon)
- South Bay Combined Cycle - L.S. Power
- Starwood Power - Starwood Power-Midway LLC
- Sunrise - Texaco & Edison Mission E.
- Sun Valley Energy Project - Edison Mission Energy
- Sutter - Calpine

- Tesla Combined Cycle - FPL
- Tracy Peaker - GWF

Example Plant Data Sources

- Plant layouts, turbine selections, cooling technology, water supply, and other details are available in documents on the Energy Commission website at *http://energy.ca.gov/sitingcases*.
  - The *Database of California Power Plants* provides a comprehensive list in spreadsheet form.
- EPA eGRID and DOE EIA databases provide unit-by-unit data on rated capacity, fuel consumption, CO_2 production, etc.
  http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
  http://www.eia.doe.gov/bookshelf.html


Final Staff Assessment

COLUSA GENERATING STATION

Application For Certification (06-AFC-9)
Colusa County

CALIFORNIA ENERGY COMMISSION
DOCKET 06-AFC-9
DATE
RECD. NOV 30 2007

STAFF REPORT

NOVEMBER 2007
(06-AFC-9)
CEC-700-2007-003-FSA

PROOF OF SERVICE (REVISED 8/22/07) FILED WITH
ORIGINAL MAILED FROM SACRAMENTO ON 11/30/07
MS

PG&E's Role in the Natural Gas – CCS Study

Emma Wendt
Pacific Gas and Electric
Emerging Clean Technologies

November 3, 2010

Carbon capture & storage: Outline

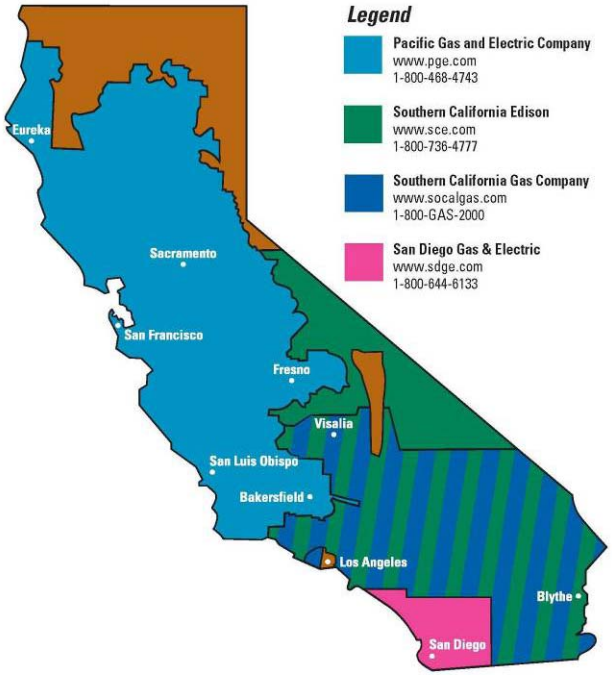
1. About PG&E
2. Why PG&E is interested in CCS
3. PG&E's role in the study
4. Questions

PG&E: a large and green utility

Named by Newsweek as the **greenest utility in America**

Serves **5% of the U.S. population**; **emits < 1% of the total CO_2** emitted by the utility sector

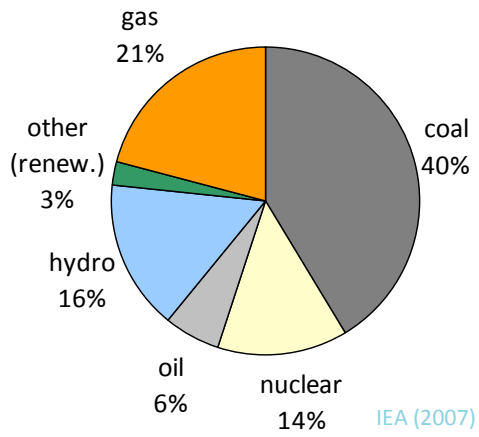
Connected more solar customers than any other utility in the country — > 43,000 customers have solar installed; ~40% of total in U.S.



Employees	**19,800**
Electric and gas distribution customers	**5.1 MM electric 4.2 MM gas**
Electric transmission circuits	**18,610 miles**
Gas transmission backbone	**6,136 miles**
Owned electric generation capacity	**6,000+ MW**
Total peak demand	**20,000 MW**

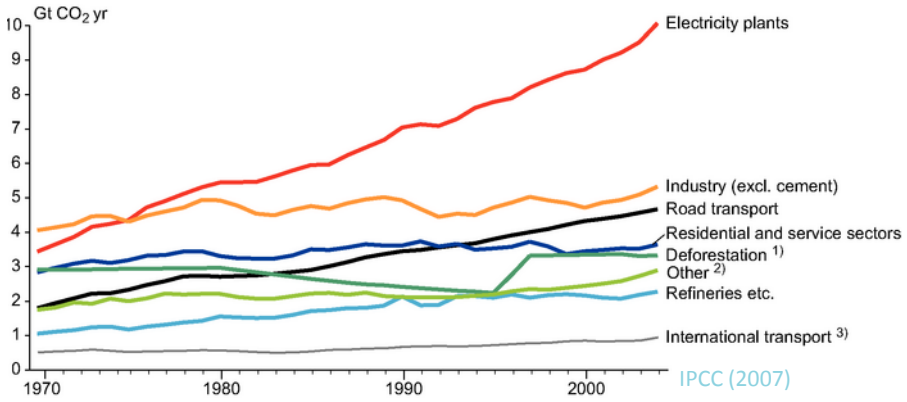
We need to reduce GHG emissions, but existing fossil fueled plants are likely to be here for a while

40% of global electricity production comes from coal,



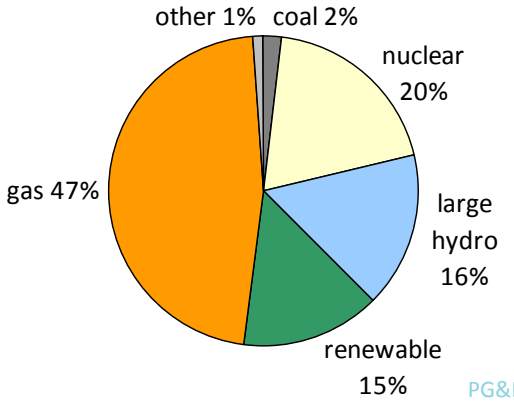
IEA (2007)

and emissions keep increasing



IPCC (2007)

PG&E's electricity mix is relatively clean, but still half our generations is from fossil fuels



PG&E (2009)

We either
1. pay for allowances,
2. switch entirely to green power, or
3. get rid of our emissions

If we want to stabilize our climate, we have to reduce emissions using a portfolio approach

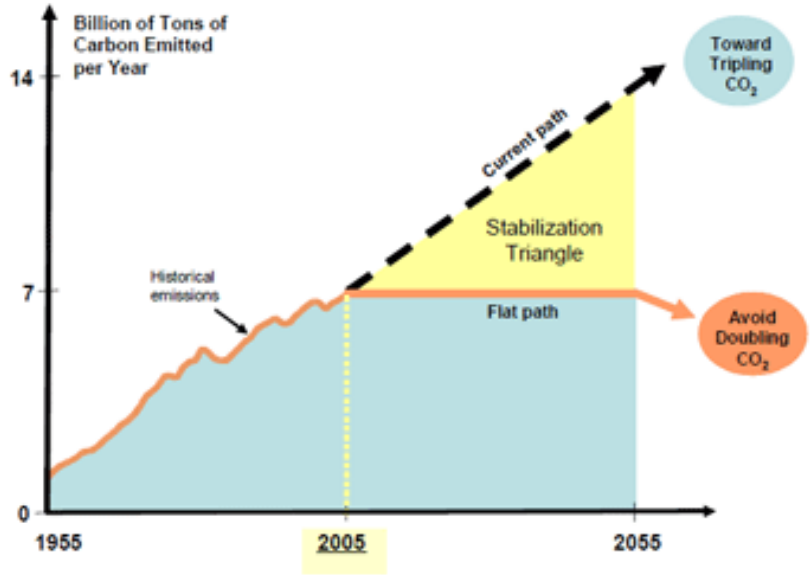


Figure 1

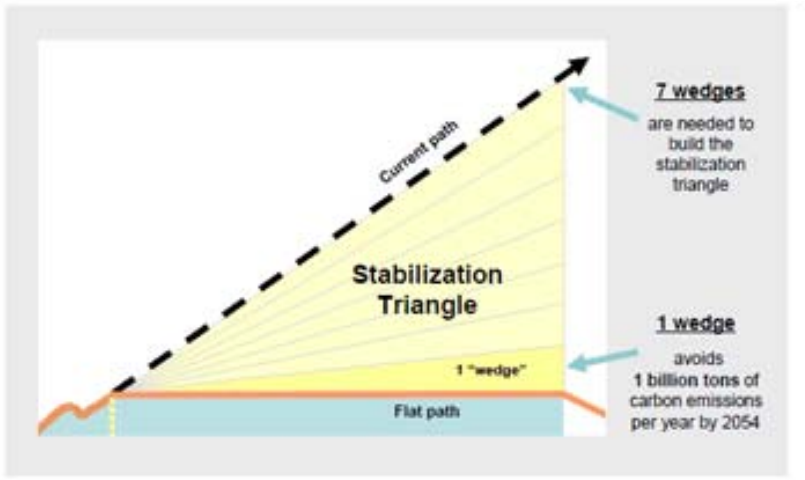


Figure 2

Socolow and Pacala, Princeton

1 wedge = capture and store emissions from 800 coal electric plants.

We want to understand the potential for CCS in California

PG&E's **goal**:

To understand the **costs**, **technical feasibility** and **potential** for retrofitting natural gas power plants with CCS

PG&E's **contribution**:

Staff **time**

Power plant **information**

Questions?

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West Coast Regional Carbon Sequestration Partnership

LLNL Role and Tasks

Jeff Wagoner
Lawrence Livermore National Laboratory

California Energy Commission
NGCC Pre-Bid conference
November 3, 2010

LLNL tasks focus on geologic characterization

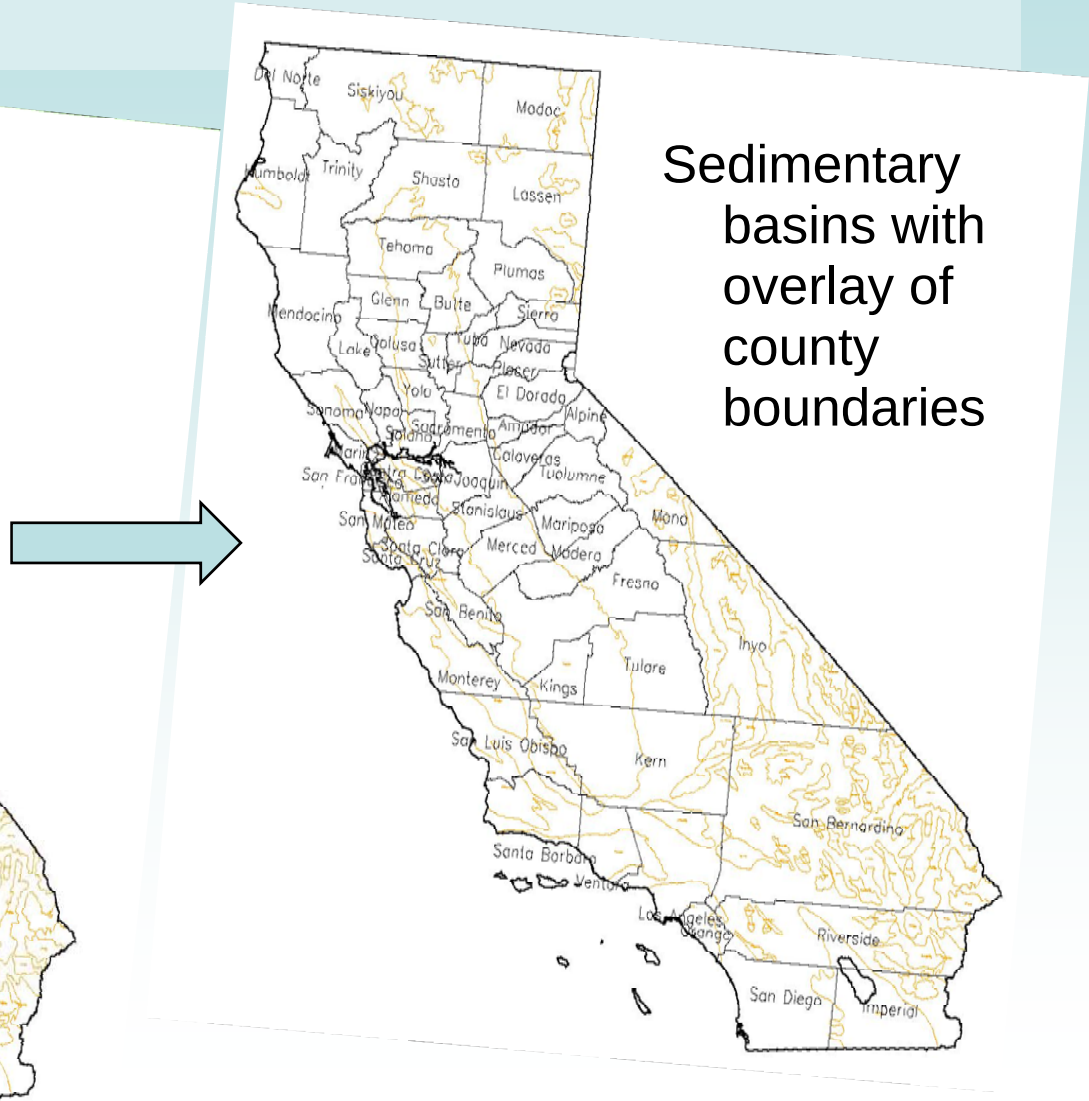
- Review the geology of each power plant site under consideration in California
- Each site will be evaluated based on a set of geologic criteria
- The area of review will be a 50km square centered at the power plant
- Detailed 3D geologic models will be constructed for selected plant sites.

Geologic criteria include:

- Depth to bedrock
- Proximity to active faults
- Seismicity of the area
- Depth to base of freshwater(<10,000 TDS)
- Presence of storage capacity
  - in depleted oil and gas fields
  - in saline formations
- Presence of thick sealing rock units above the storage formation
- Land ownership/use

Geographic and geologic criteria are overlain successively

Sedimentary basin outlines

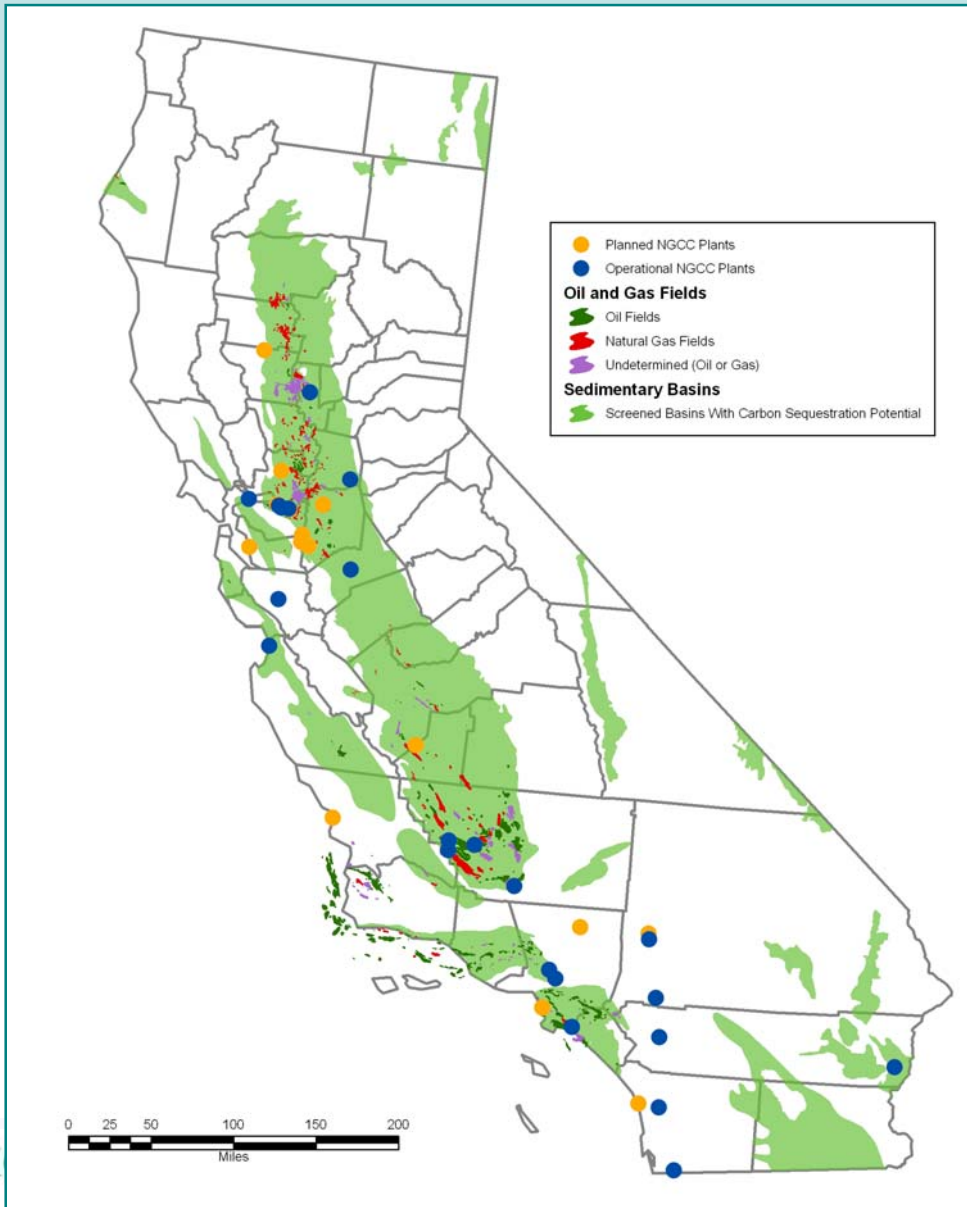


Sedimentary basins with overlay of county boundaries

Successive overlays suggest a first-cut elimination of some locations

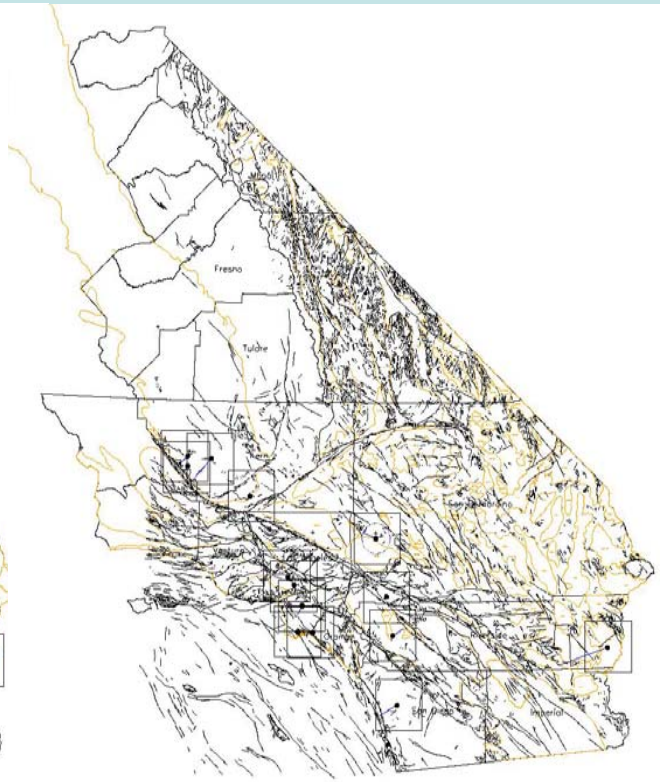
Layers applied include:

- Power plant locations
- Sedimentary basins with some land use screening
- Oil fields
- Natural gas fields
- County boundaries for reference

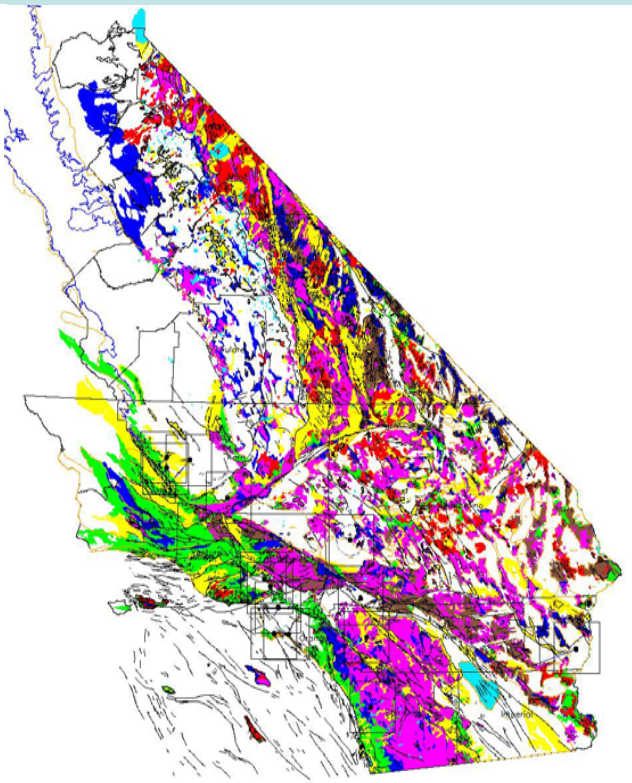


Adding more geologic features quickly adds complexity: Southern CA example

County boundaries, sedimentary basins and 50 Km square areas of review for plant locations



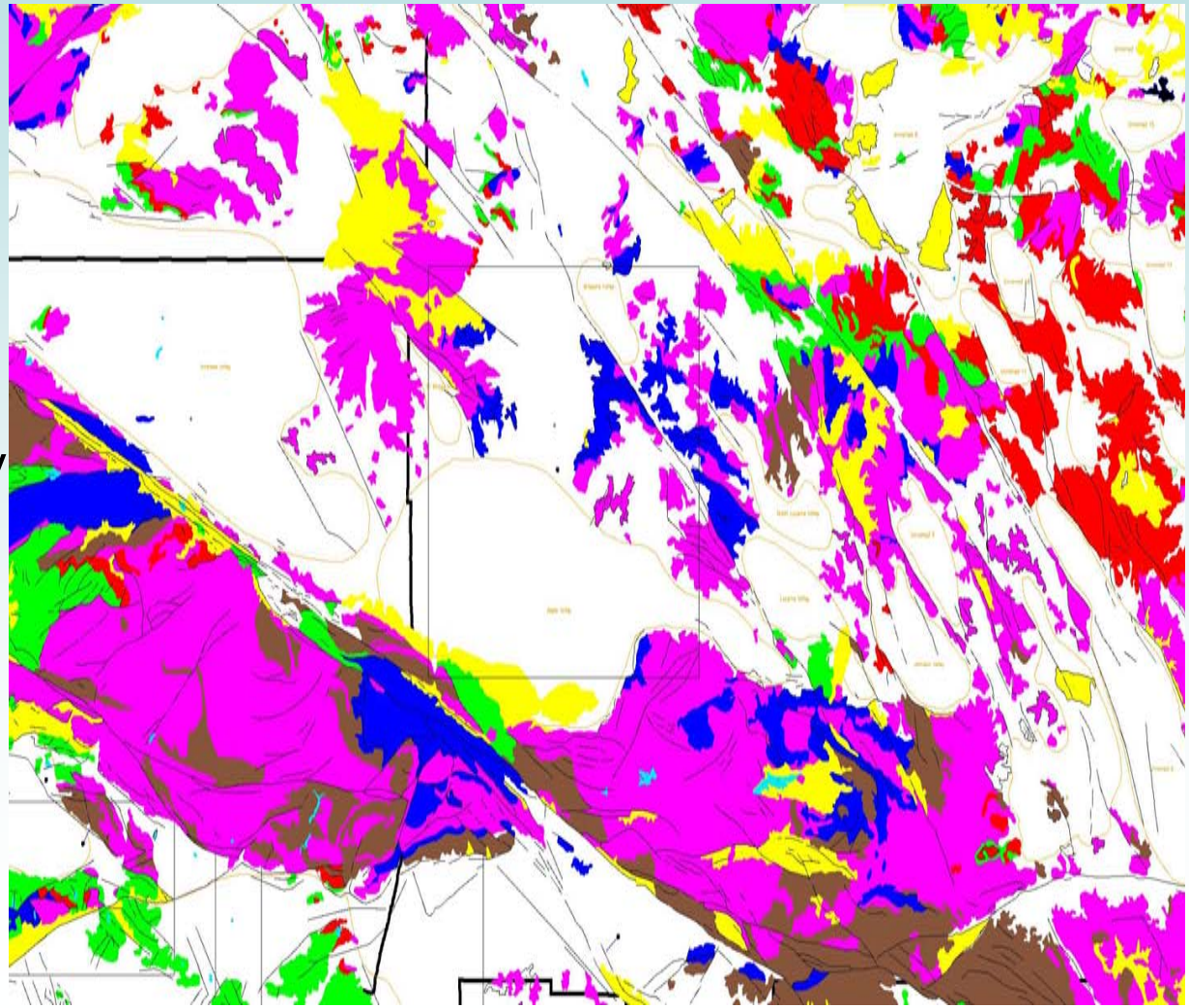
With surface faults added



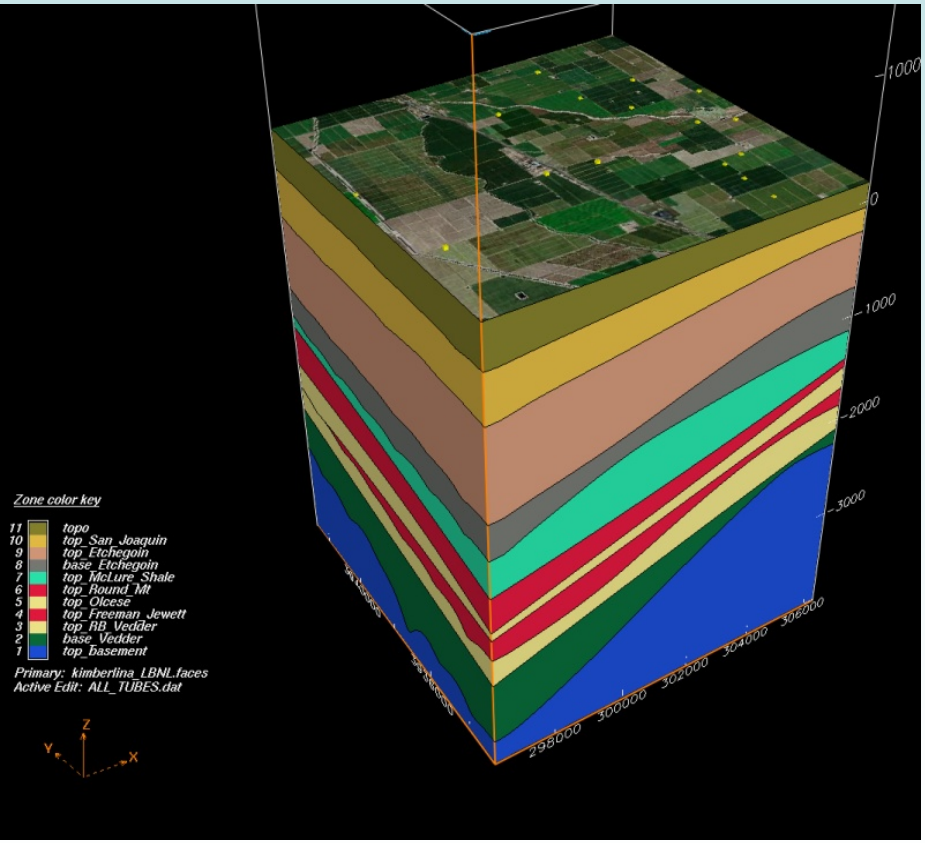
With surface geology (rock type and age) added

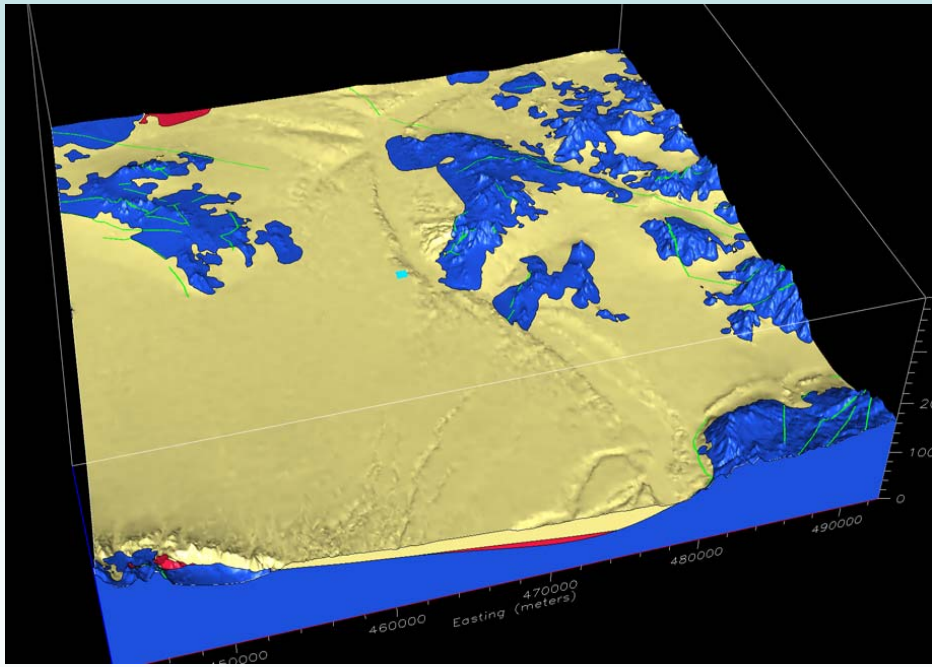
Close-up of 50 km square area of review around a power plant in Mojave Desert

- granitic intrusives
- pre-Tertiary sedimentary rocks
- Tertiary sedimentary rocks
- Alluvial sediments
- Volcanic rocks



Within areas of review, well data and seismic data are used to construct a 3-D model which includes surface and subsurface





Power plant sites overlying a thick sedimentary sequence (left) and overlying basement (above)

LLNL will work with the contractor and the Energy Commission to provide

- Geologic criteria for site screening and down-selection
- Geologic screening of power plant sites
- 3-D models of a (few) best site(s) that pass screening based on engineering and geologic criteria
- Capacity estimates of storage for best site(s)
- Project review and reporting materials as requested